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Ensemble Variational Bayesian Uncertainty Quantification for High Dimensional Nonlinear Parameter Inversion of Darcy Flows in Porous Media

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The inversion and uncertainty quantification of parameters associated with governing PDEs are important in many scientific and engineering problems. For example, petroleum reservoirs are typically heterogeneous and uncertain due to the sparsity of hard data, and the uncertainty quantification of physical parameters associated with the governing PDEs of flows in porous media, given production history data, is a necessary step before reasonable forecasts can be made. Conventional history matching inversion methods are generally point-estimate, while uncertainty quantification using MCMC is computationally expensive. In the current study, an efficient ensemble variational Bayesian (EVB) uncertainty quantification method is developed for inverting high-dimensional parameters for the governing PDEs. Variational Bayes inference approximates the posterior using trial distributions such that the Kullback-Leibler divergence between the true posterior and the trial distribution can be minimised. In EVB, a reduced-order model is built using principle component analysis to enhance the convergence of small-size ensembles. The trial distribution is optimized simultaneously as the ensemble of realizations are updated by data assimilation. In particular, particle filtering is adopted for the nonlinear inverse problem under consideration. Two- and three-dimensional test cases of single- and two-phase Darcy flows in petroleum reservoirs are presented for validation.

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References

Conference Proceedings

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